MINE SUBSIDENCE AND THE HISTORY OF COAL MINING IN THE MAHONING VALLEY

A Senior Thesis submitted in partial fulfillment
of the requirement for the degree
Bachelor of Science in Geology

By

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ACKNOWLEDGEMENTS

Ann G. Harris is currently Associate Professor of Geological Sciences at Youngstown State University. She is a member of the American Institute of Professional Geologists and serves as Consulting Geologist to the mine subsidence problem for the State of Ohio. She is responsible for advising on the history, geology, and proper stabilization techniques for abandoned underground mines and entryways throughout the Mahoning Valley. She also is helping the state determine the outcrop pattern and elevation of the Sharon coal throughout the area.

Much thanks is to be given to Ann Harris for her help, concern, and encouragement; without it this paper would not be able to reveal the full impact of this problem.

Additional thanks go to my thesis advisor Dr. Russell O. Utgard for his professional guidance and to my parents for making my education possible.

ABSTRACT

Abandoned underground coal mines and their entryways are a potential danger to public landowners due to the improper sealing and mining methods incorporated upon the closure of mining operations in the late 1800's. A study of the Mahoning Valley coal field (Trumbull and Mahoning Counties) was made to determine the causes of mine subsidence, an increasing problem that has plagued the area since 1977. Coal mining thrived in this area from the mid to late 1800's and the mines were located in the Sharon #1 coal.

The objective was to study mine subsidence in the Mahoning Valley which led to a study of the history and geology of coal mining in the area. Evidence was found that the Sharon coal exists as a basin coal restricted to subsurface valleys and lowlands that were created by the pre-Pennsylvanian erosion. This restriction made the Sharon coal very difficult to mine but the high quality of the coal yielded high profits. The coal was used as a furnace fuel in local blast furnaces for the smelting of iron ores and was therefore a major reason for the develcpment of the steel industry throughout the Mahoning Valley.

The state is now providing funding for the reclamation of these abandoned mines and entryways. The state is also making an effort to locate the Sharon coal's outcrop pattern and elevation in order that proper advise can be given to building programs so they are not in jeopardy of subsidence damages. Consulting geologist to the program, Ann G. Harris,

is involved in state efforts to secure this area from subsidence problems. She remarks that the program has had very successful results but adds that there is a need for more state funding to go to each stabilization job and to do more test drilling to find the outcrop pattern of the Sharon #1 coal.

I. INTRODUCTION

Problem

Increased underground mine subsidence is a major problem throughout the Mahoning Valley. Subsidence is occurring over drift, slope, and shaft entryways and over the rooms and tunnels of abandoned underground coal mines. The subsidence began in 1977 when a shaft entryway collapsed claiming the garage of a Youngstown resident. In August of 1977 the federal government passed a bill which allocated funds to stabilize land that has been damaged by previous mining operations. In the Mahoning Valley the main goals of this program are:

1. The stabilization of abandoned underground entryways and mines.
2. Determining the outcrop pattern of the Sharon coal throughout the area.

The subsidence problem is accelerated because very few records or maps of the past mining operations were kept. People have built their homes over past mining areas without knowledge and are now in danger of subsidence damages.

Purpose and Scope

The purpose of this paper was to investigate the mine subsidence problem in the Mahoning Valley. This lead to a study of the history and geology of the coal mining operations that flourished in the Mahoning Valley 100 years ago. A geological study was necessary to understand the nature of the

Sharon coal. Its elevation, distribution, area extent, and its outcrop pattern are discussed. A historical study of the mining operation is necessary to understand the methods used to mine this coal. Reasons as to why the coal was mined, what it was used for, and how much was mined will also be discussed, The main objective of this report is to analyze why there is a subsidence problem, what is being done about it, and how it is being done. Recommendations as to additional needs for this program will also be cited.

II. STRATIGRAPHY

Designation

The Sharon #1 coal is the lowest member of the 11 numerically designated coal seams of the Ohio coal field (Fig. 1). These numerical designations were introduced by Newberry (1874: 130) in 1874 for convenience. He numbered those seams which are of mineable importance, all others occur only locally within certain strata of the state.

Distribution

The Sharon #1 coal lies in the northeastern portion of the Ohio coal field (Fig. 2). It thins southward into the basin of the Ohio coal field but is only of mineable importance to the seven northeastern counties of Mahoning, Trumbull, Portage, Summit, Stark, Medina, and Wayne. Although a single field of small extent, comparable to the Sharon's horizon, is located in Jackson County (Southern Ohio) its actual progression into the Great Appalachain Coal-Field is problematic (Orton, 1884:157).

Stratigraphic Location

The Sharon coal is a member of the Pottsville Group, the first forming rocks of the Pennsylvanian System (Fig. 3). The upper boundary of the Sharon coal is the base of the Sciotoville clay with the lower boundary being the Sharon conglomerate. The upper boundary of the Pottsville Group is the top of the Homewood sandstone and the lower boundary is the base of the Sharon conglomerate, which is an unconformity.

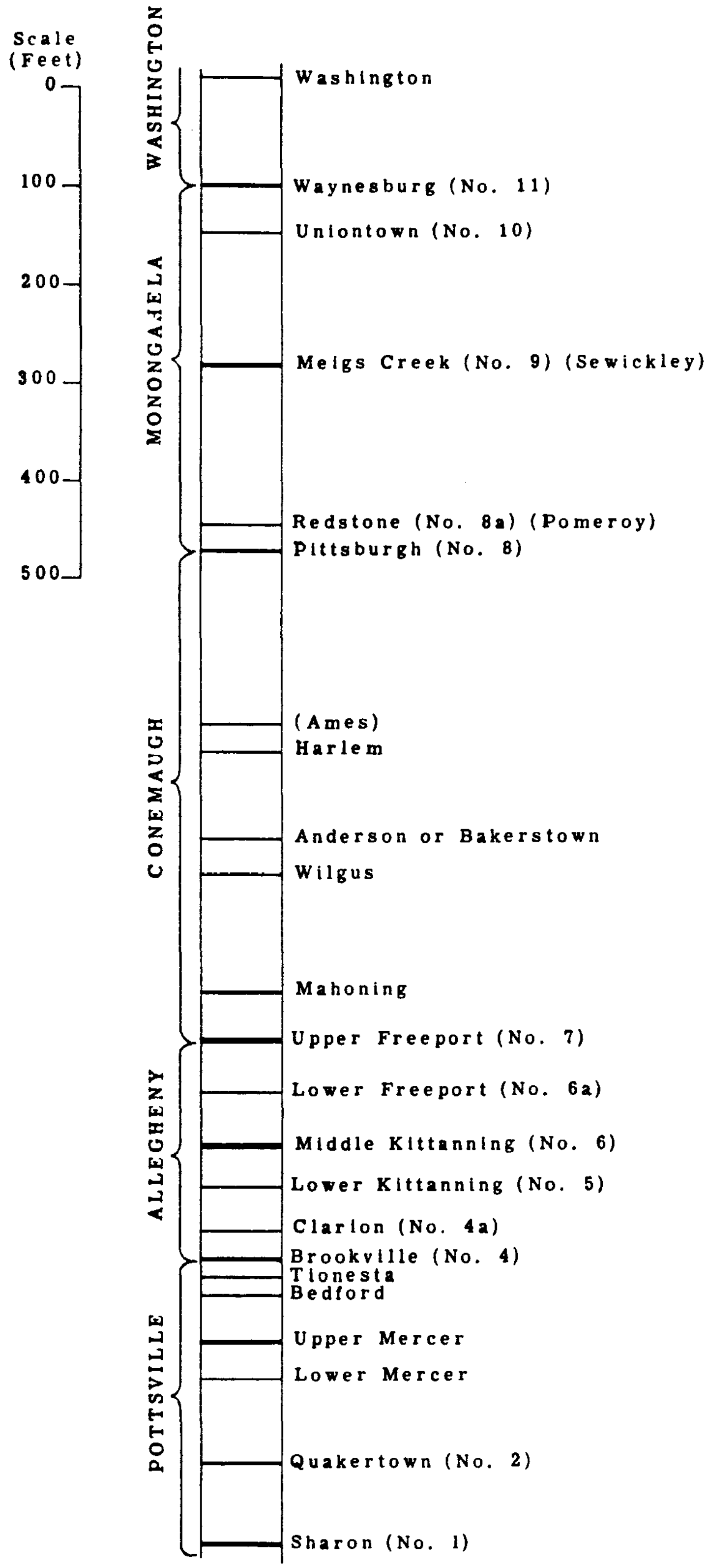


Figure 1- Generalized geologic section of Ohio coals.
(O.G.S., 1960:24)

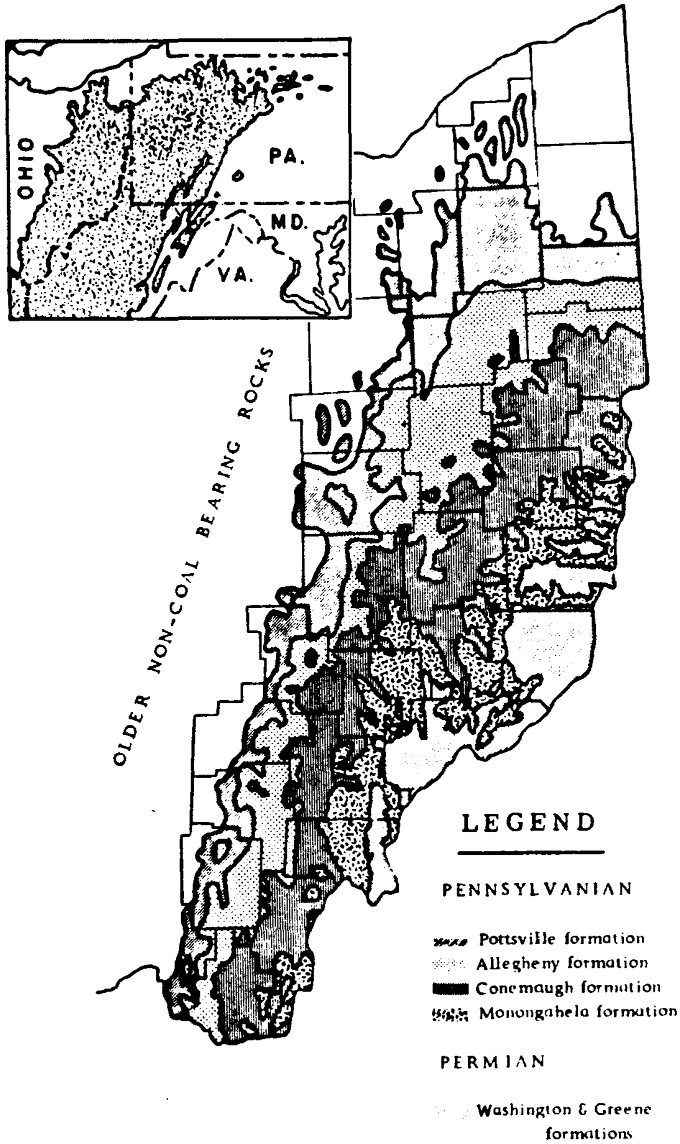


Figure 2- Generalized geologic map of the coal producing areas of Ohio. (O.G.S., 1960:22)

		Upper Freeport No. 7	Coal, patchy	3	0		
			Clay and shale	7	0		
		Upper Freeport	Limestone and marly shale	2	0	12	3
		Bolivar	Coal, local, thin		3		
		Bolivar	Clay, flint and plastic	5	0		
		Upper Freeport	Shale or sandstone	33	0	39	0
		Lower Freeport, Rogers	Coal, patchy	1	0		
			Clay, impure	2	6		
		Lower Freeport	Limestone, local	1	0	29	6
Pennsylvanian		Lower Freeport	Shale or sandstone	25	0		
		Upper Kittanning	Coal, seldom present	1	0		
			Shale and sandstone	10	0		
		Washingtonville (Yellow Kidney ore)	Shale, marine	4	0	18	0
		Middle Kittanning No. 6	Coal, persistent	4	0		
			Clay, siliceous	3	6		
		Salem	Limestone, impure, local		6	14	6
		Red Kidney ore	Shales, siliceous	10	0		
		Strasburg	Coal, local		6		
		Oak Hill	Clay, flint and plastic	4	0		
			Shales, siliceous	3	0	13	4
		Hamden	Limestone, unsteady, marine	4	0		
	Allegheny	Lower Kittanning No. 5	Coal	2	4		
			Clay, plastic	5	0	5	4
		Lawrence	Coal, shaly, local		4		
			Clay, flint and plastic	6	0		
		Kittanning	Shale and sandstone	8	2		
		Ferriferous	Ore, irregular		8	21	4
		Vanport	Limestone, marine	6	0		
		Scrubgrass	Coal, seldom present		6		
			Shale, carbonaceous	5	0	9	0
		Clarion No. 4a	Coal, patchy	4	0		
			Clay, flint and plastic	5	0		
		Canary	Ore, very local		6	17	0
		Clarion	Sandstone, irregular	10	6		
		Winters	Coal, very local	1	0		
		Zaleski	Flint, impure, marine	1	0	2	0
		Ogan	Coal, local	1	0		
			Shale and sandstone	25	0		
		Putnam Hill	Limestone, marine	4	0	31	0
		Brookville No. 4	Coal, steady	2	0		
						212	3
			Clay, plastic	4	0		
		Homewood	Shale or sandstone	10	0	15	0
		Tionesta No. 3b	Coal, local	1	0		
			Clay, plastic	5	0		
			Shale and sandstone	24	0		
		Upper Mercer, Big Red Block	Ore, irregular		4	32	0
		Upper Mercer	Limestone or flint	1	8		
		Bedford	Coal, patchy	1	0		
			Clay, siliceous	3	0		
			Shale and sandstone	7	0		
		Sand Block	Ore, siliceous, local		6	15	0
			Shale and sandstone	3	6		
		Upper Mercer No. 3a	Coal, local	1	0		
			Clay, siliceous, plastic	3	0		
			Shale and sandstone	11	0		
		Lower Mercer, Little Red Block	Ore, Kidney		3		
			Shale, siliceous	1	9	18	6
		Lower Mercer	Limestone, steady, marine	2	0		
		Middle Mercer	Coal, steady, thin		6		
			Clay, siliceous, plastic	3	6		
			Shale and sandstone	5	0	9	0
		Flint Ridge	Coal, thin, local		6		
			Clay, plastic and flint	4	0		
			Shale and sandstone	5	0		
		Boggs	Ore and limestone, marine		6	11	6
			Shale, siliceous	1	0		
	Pottsville	Lower Mercer No. 3	Coal, steady, thin	1	0		
			Clay, siliceous	3	0		
			Shale and sandstone	23	0	28	0
		Lowellville, Poverty Run	Limestone or ore, marine	1	0		
		Vandusen	Coal, thin, unsteady	1	0		
			Clay, impure	2	0		
			Shale and sandstone	17	0	20	6
		Bear Run	Coal, local	1	6		
			Clay, siliceous	3	0		
		Connoquenessing or Massillon	Shale or sandstone	24	0	29	0
			(*Jackson*, *Sand Block*, and *Lincoln* ores in interval)				
		Quakertown No. 2	Coal, patchy	2	0		
			Clay, siliceous	5	0		
			Shale and sandstone	12	0	17	3
		Huckleberry	Coal, thin, local		3		
			Clay, siliceous	3	0		
			Shale, argillaceous	1	0	10	3
		Guinea Fowl	Ore, local		3		
			Shale, gray, siliceous	5	9		
		Anthony	Coal, thin		3		
		Sciotoville	Clay, flint and plastic	4	0		
			Shale and sandstone	20	0		
		Sharon	Ore, local, marine		3	32	0
			Shale, siliceous	4	9		
		Sharon No. 1	Coal, patchy	3	0		
			Clay, impure	2	0		
			Shale, siliceous, irregular	5	0	18	0
		Sharon	Conglomerate, patchy	10	0		
		Harrison	Ore, local, impure, marine	1	0		
						256	0

Figure 3- Stratigraphic section of Pottsville Group. (O.G.S., 1960:22)

Total thickness of Pottsville strata is reported to be 256 feet but it is frequently much less as it occurs in the Mahoning Valley. Oil well records from Columbiana County have reported the maximum thickness of the Pottsville Group to be approximately 200 feet (Stout, 1924:51).

The Pottsville Group

The Pottsville Group of the Mahoning Valley consists of sandstones, clays, iron ores, coals, and limestones. Of these rock types it is the sandstones and shales which dominate. They show notable variations both horizontally and vertically and commonly grade into one another over short distances. The Sharon conglomerate which occupies the base of the Pottsville strata in the Mahoning Valley shows the greatest variation. It lies only in the basins or valleys that were created by the pre-Pennsylvanian erosion and is often truncated against these hills before it can rise to any considerable height. The dominant limestone in the area is the Lower Mercer limestone. "It is by far the most persistent, uniform, and easily recognized unit in the Youngstown region (Stephenson, 1933: 79)." It maintains a rather constant thickness of about two feet six inches and provides the best correlation datum throughout the Mahoning Valley. Of the 11 or 12 local coals found in the Mahoning Valley it is only the Sharon coal that maintains the quality and thickness needed for mining. Because it lies in the lower Pottsville it is greatly affected by the pre-Pennsylvanian erosion and therefore occupies only the basins and lowlands of adjacent hills (Stephenson, 1933).

III. OCCURRENCE AND PALEOENVIRONMENT

The Unconformity

In the Mahoning Valley the base of the Sharon conglomerate represents the Pennsylvanian-Mississippian unconformity. The extent of the pre-Pennsylvanian erosion in the Mahoning Valley has been reported by Stephenson (1933:50) to reduce the Mississippian strata by about 350 feet of its original 800 feet. This erosion produced great relief in the form of hills and valleys (Fig. 4). The erosion profoundly affected the deposition of the lower most members of the Pottsville Group and in turn accounts for approximately 100 feet thickness variation of total Pottsville strata throughout the valley (Stephenson, 1933:59). An excellent example showing this variation is provided by Brant and DeLong (1960:31) where they reported the Sharon conglomerate of Trumbull County to "vary in thickness from a few feet to about 60 feet." This erosional topographic variation also had a profound effect on the deposition of the member in study, the Sharon #1 coal.

The Sharon #1 Coal

The depositional character of the Sharon coal is best described as a "basin" coal confined to the valleys and lowlands created by the pre-Pennsylvanian erosion. The total area of these basins varies considerably but an average distribution of 200 acres has been reported by Orton (1884:156). The thickness variations and lateral distribution of these basins has best been described by Orton (1884:156).

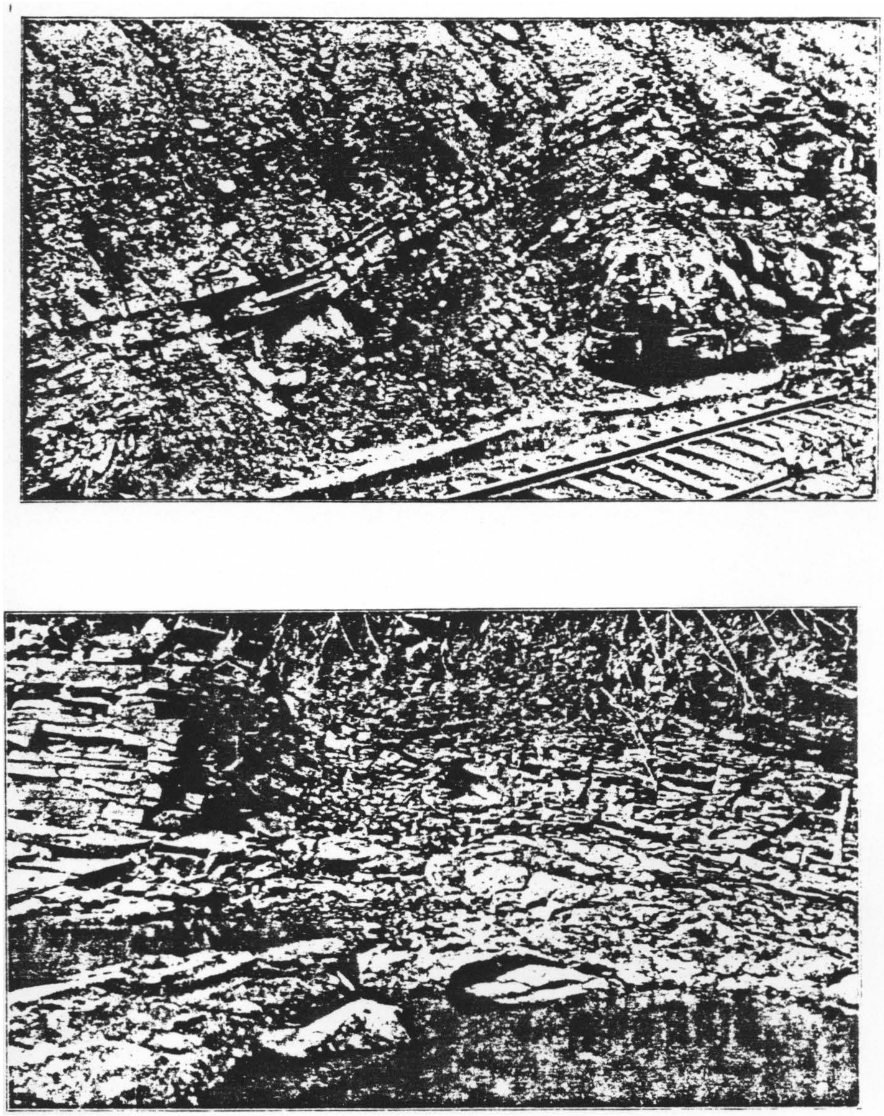


Figure 4- Pennsylvanian-Mississippian Unconformity, Wayne County. (G.S.O., 1921:92 & 94)

> Where the seam has good fortune, its thickness ranges from four to six feet. It occasionally gains a foot upon these measurements, but it does not hold the increase long. It is everywhere a seam of "swamps" and "hills," the latter rising 20,30, or even 40 feet above the lower and more productive portions of the seam. In ascending these hills, the coal rapidly loses height as a rule, and frequently entirely disappears.

An excellent example of how the Sharon coal exists in its basin is shown by figure 5. Figure 5 was produced by the Ohio State Inspector of Mines Annual Report (1876:137) from borehole data that appeared in the Geological Survey of Ohio (1873:498). Table 1 shows the 11 drill holes that were made by the Brookfield Coal Company on land in Brookfield Township, Trumbull County.

TABLE 1:

BOREHOLE #	LOCATION ABOVE OR BELOW DATUM
1	4.72 feet below
2	1.45 feet above
3	1.90 feet below
4	1.02 feet above
5	14.36 feet below
6	1.12 feet below
7	28.38 feet below
8	12.50 feet below
9	13.50 feet below
10	24.13 feet below
11	54.30 feet below

The coal was first located 80 feet below the surface and this point was used as a base datum. The remaining figures (Table 1) represent how far above or below the datum the coal was found in the 11 boreholes. Although there was no scale

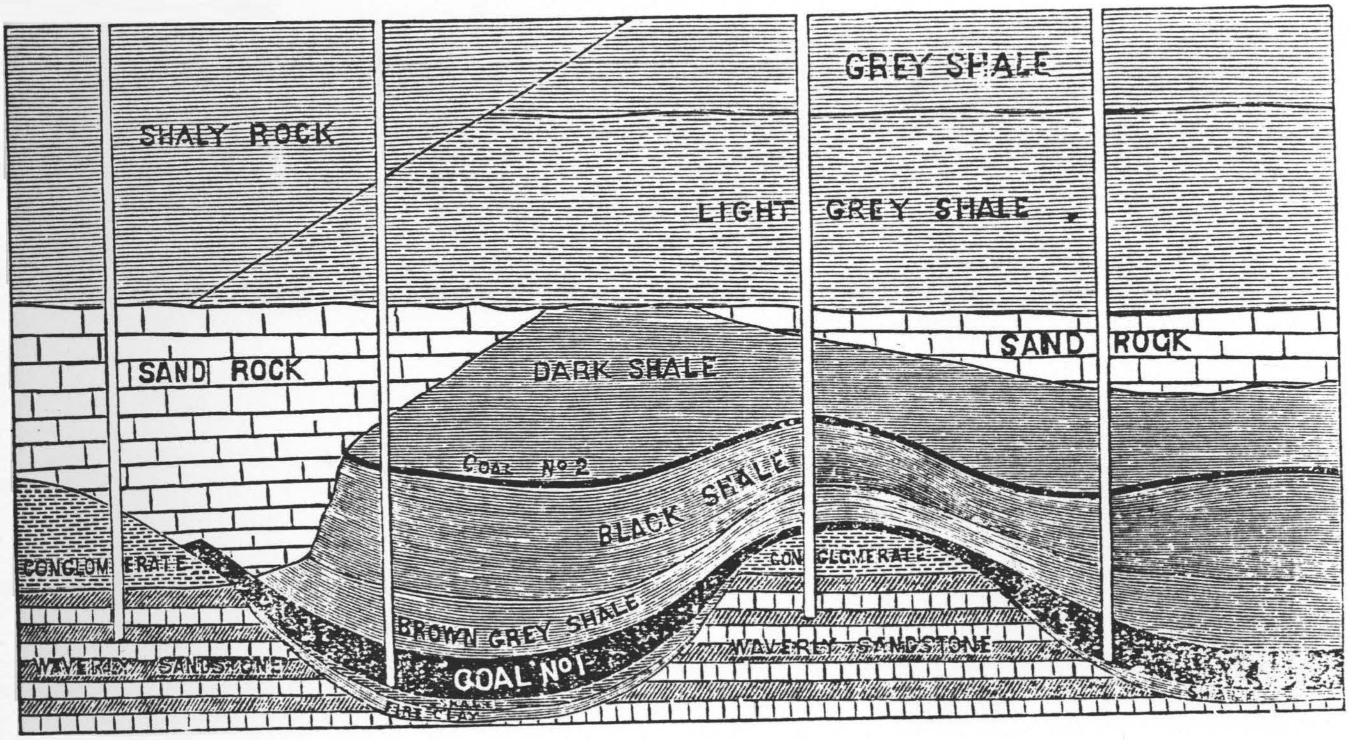
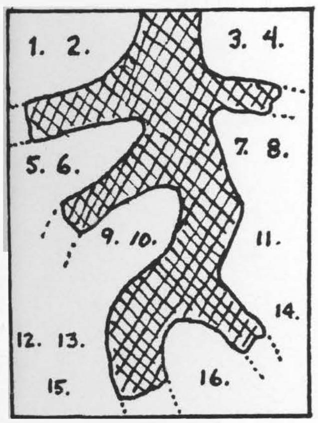


Figure 5- Basinal characteristic of Sharon #1 coal. (S.M.I., 1876:137)



1. Shaded portion indicates mined area of 60 acres that has produced excellent quality coal.

2. Numbers 1 through 16 indicate area where no coal was located in borings.

3. Dashed lines indicate area where coal thinned and was unable to mine.

Figure 6- Plat of Crawford, Davis, & Co.'s Mine, Hubbard Township. (G.S.O., 1873:496)

provided for figure 5, it represents the discontinuity of the Sharon coal well. Another good example showing the characteristics of the Sharon coal is provided by the Crawford, Davis, and Co.'s mine of Hubbard Township, Trumbull County (Fig. 6). Although this plat is only a rough sketch of the whole mine it displays the sinuosity of the Sharon coal very well. If a cross-section of the plat were made it would probably be very similar to figure 5 showing that the unshaded portions of the plat occupied the areas where the subsurface basins began to rise up the hills resulting in the Sharon coal to thin out or become truncated.

IV. CLASSIFICATION OF THE SHARON COAL

Type and Use

Ohio bituminous coals of the late 1800's were classified as open-burning (furnace coals), cementing coals (coking coals), or cannel coals. The Sharon #1 coal is classified as as opening-burning or furnace coal because of its ability not to coke or adhere inside the blast furnace. Throughout the mid to late 1800's it was used in raw state in blast furnaces for the manufacture of iron. "As it occurs in the Mahoning Valley, it is a type and standard of the class to which it belongs, and is one of the best furnace fuels known, half the iron produced in the state (1874) being made with it (Newberry, 1874:123)." The Middle Kittanning #6 coal of Steubenville being the only other coal in the lower coal measures of this character.

Quality

The quality of the Sharon coal was the main cause for its extensive mining in the 1800's particularly in the Mahoning Valley where it has its best development (Newberry, 1874:132). In the Mahoning Valley the Sharon coal is referred to as the Brier Hill coal and is said to be superior to the coal of all other areas (S.I.M.,1875:25). It is here that the Sharon coal has received the name "Block coal" because it is very compact and mines in large rectangular blocks. Because of its block character larger quantities of lump and nut coal was able to be mined over slack. In 1891 Mahoning and Stark counties reported approximately six times more lump and nut coal over slack (R.O.M.I.,1891:9). This statistic alone was of utmost importance to the early miners because they were often paid higher premiums for lump and nut coal because slack was of no real use at the time.

The chemical analysis of the Sharon coal also accounts for its high ranking. In general, coals which have low values of sulphur, ash,and moisture and high values of fixed carbon and volatile combustibles are more valuable. The following chemical analysis of the Brier Hill coal of Youngstown is provided (Orton, 1884:120).

TABLE 2: CHEMICAL ANALYSIS OF BRIER HILL COAL.

VARIABLE	PERCENT
Moisture	3.60
Volatile and Combustible Matter .	32.58
Fixed Carbon.	62.66
Ash.	1.16
	100.00
Sulphur	0.85

Like most coals the quality of the Sharon coal shows variations over given areas. This is displayed by the average chemical analysis of the Massillon coal field of Summit and Stark counties (Orton, 1884:777).

TABLE 3: CHEMICAL ANALYSIS OF MASSILLON COAL.

VARIABLE	PERCENT
Moisture	5.50
Volatile and Combustible Matter .	37.00
Fixed Carbon.	53.50
Ash.	4.00
	100.00
Sulphur	1.10

Although the amount of ash and sulphur is higher than that of the Brier Hill coal it is by no means inferior in quality. It is of open-burning character and its analysis shows that it deserves ranking among the very best coals of the state. The Massillon coal has long been used as a successful fuel in local blast furnaces for the smelting of iron ore (Orton, 1884:778).

For means of comparison a chemical analysis has been provided for the Flint Ridge #4 cannel coal (Newberry, 1874:142). It is mined in Coshocton County and is described as a cannel coal of "good" quality.

TABLE 4: CHEMICAL ANALYSIS OF FLINT RIDGE CANNEL COAL.

VARIABLE	PERCENT
Moisture	2.60
Volatile and Combustible Matter .	40.20
Fixed Carbon.	44.00
Ash.	13.20
	100.00
Sulphur	1.34

Cannel coals are chiefly used as household fuels, they are usually denser and homogeneous in texture, but not well adapted for coking or furnace fuels due to high values of ash and sulphur.

The Mineral Ridge Field

The greatest degree of local variation observed within the Sharon coal is found in the mines of Mineral Ridge, located just northwest of Youngstown. A generalized section of the mineral Ridge mining field appears below.

TABLE 5: SECTION OF MINERAL RIDGE COAL FIELD (Orton, 1884:174).

TYPE	THICKNESS VARIATION
1. Mineral Ridge Coal, Coking	0' to 4'
2. Blackband Iron Ore	0' to 1'
3. Black Slate, called "Wide Awake"	0' to 2'
4. Block Coal, Open-Burning.	6" to 2.5'

The lowest bench is recognized as the block coal of the Mahoning Valley. Although its thickness never exceeds 2.5 feet it maintains its superior quality much the same as the Brier Hill coal of Youngstown (S.M.I.,1876:133).

Moving up in section the Wide Awake black slate is found. It varies in thickness from zero to two feet and is always present whenever the Blackband ore is found.

The next zone encountered is the Blackband iron ore. It varies in thickness but reaches a maximun thickness of 12 inches when found in the central portions of the coal basin. When this iron ore is mined in the basin it yields a ton of ore per ton of coal but one ton of iron ore per three tons of coal is its overall average (S.M.I., 1876:134). The Blackband iron ore has proved to be an important element in the economic resources of the Mahoning Valley. This iron ore is used with "the rich ores of Lake Superior making a very special brand of iron known in the market as 'American Scotch' (S.M.I., 1876:134)." The Blackband alone was the most important element in the Mineral Ridge mining field and if it were not for its presence most of the mines in the area would have closed and not opened up again (Orton, 1884:174).

The uppermost zone is the Mineral Ridge coking coal. It varies in thickness from zero to four feet and is of a very different grade than that of the block coal found below. It is much softer and more impure and often exhibits a slight cementing character (Orton, 1884:174).

V. MINING METHODS

The Way Into the Mine

There were three methods of making an entrance into the Mahoning Valley coal mines during the 1800's. These methods, classified as drift, slope, and shaft entryways, are still in use today and represent a common means for all types of mining. There are many variables considered in choosing the proper entryway but the most general ones are listed as:

1. Depth to the coal seam.
2. Regional dip.
3. Geologic structure.
4. Water conditions.

Drift entryways are most common in areas where the coal bed crops out on the surface. They are the simplest and least expensive way of making an entrance into a coal mine because no bedrock has to be penetrated. Typical dimensions of a drift entryway are 10 feet in width for one track (15-18 if two tracks are desired) and seven feet in height. With these dimensions the entryway is cut into the side of the hill through the exposed coal seam (Fig. 7). Water conditions and regional dip are the main variables that determine the position of the drift entryway. A position is chosen where the floor of the entrance has a constant upward grade so the water that accumulates will flow out by gravitation and the loaded cars are hauled out more easily. "In this method there is no expense for removing earth or for cutting through

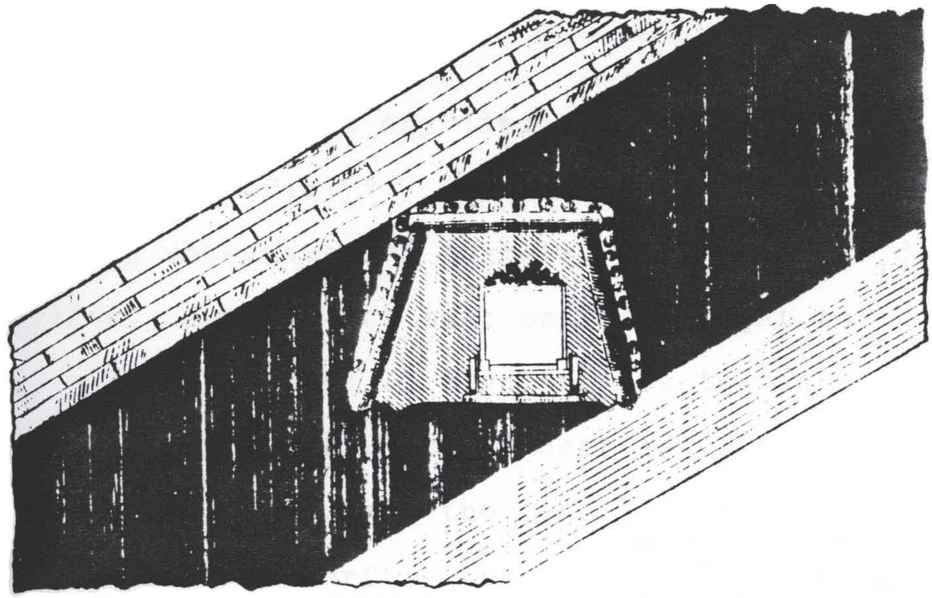


Figure 7- Generalized drift entryway. (Green, 1889:80)

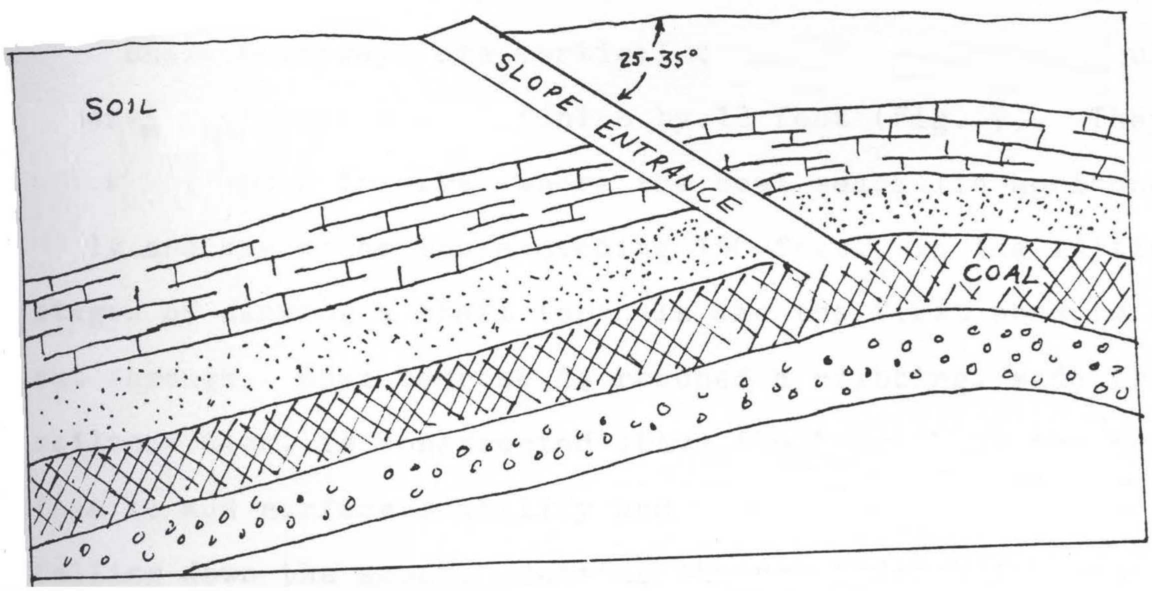


Figure 8- Generalized slope entryway.

rock, nor any cost at any time of pumping water or of hoisting coal (Green, 1889:82)."

*Slope entryways are tunnels, with the same dimensions as drifts, that are cut into bedrock to get to the mineable coal. They are bored at right angles to the dip of the coal seam with a pitch of 25 to 35 degrees (Fig. 8). Slopes are usually not opened where the coal lies at a depth exceeding 150 feet from the surface because it is more costly to sink the entrance and deliver the coal (S.I.M., 1884:20). Prior to sinking the slope it is essential that the regional dip and geologic structure be known in order to make the slope as short as possible. Since slope entryways do not allow water to flow out by gravitation, pumps must be incorporated to keep the mine dry. Timbering around slope entrances is also necessary to support bedrock walls from cave-ins.

Shaft entryways are vertical tunnels having rectangular dimensions in the range of nine by 18 feet (Fig. 9). They are most common in areas where the coal seams lie horizontally and are at depths exceeding 150 feet. In the initial stages of sinking a shaft topsoils are the first zone to be cut through. When bedrock is reached a cribbing, made from railroad ties, is constructed above the bedrock to the surface to add surface stability and to keep the soils from falling down the shaft. Cutting through bedrock is done by blasting until the coal seam is reached. Shaft entryways are the most expensive method used to reach the mine-

*--see Photos 4 & 5.

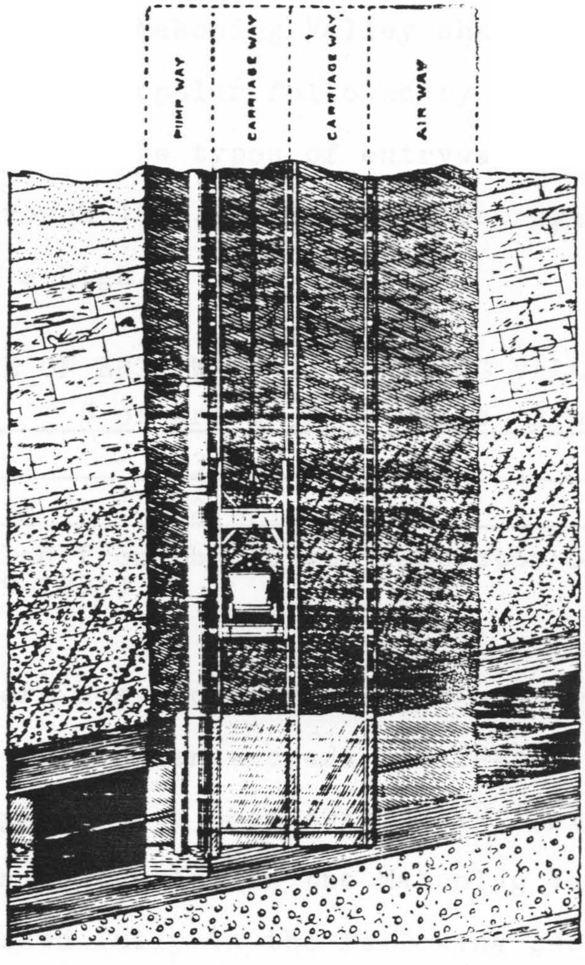


Figure 9- Generalized shaft entryway. (Green, 1889:90)

able coal because sophisticated water pumping systems and elevators must be provided (Green, 1889:88). Shaft entryways in the Mahoning Valley range from 25 to 200 feet but maximum depths of 260feet have been reported (Harris, 1985).

Throughout the Mahoning Valley shaft entryways seem to have been the most popular followed by slope then drift. Table 5 summarizes the types of entryways made from the years 1879 through 1886, a time in this region when coal mining was at a high.

TABLE 5: TYPE OF ENTRYWAYS IN MAHONING VALLEY (1879-1886).

	# of Drift	# of Slope	# of Shaft	Total
Mahoning County	3	8	21	32
Trumbull County	2	14	15	31

---Data compiled from Ohio State Inspector of Mines Annual reports, (1879-1886).

Shafts were most popular in this area because the depth to the Sharon coal often exceeds 150 feet. The different types of entryways have been critically analyzed because they present the major problem in the Mahoning Valley today, and will be discussed fully in the following sections.

Room and Pillar Mines

During the 1800's the most common method of underground mining was the room and pillar method. In this method rooms of coal were mined out and pillars of coal were left standing to support the roof. The variables which govern the size of the rooms and the thickness of the pillars are listed below.

1. Depth to coal seam.
2. Condition of the roof and floor (soft or strong).
3. Nature of the coal.

As the depth to the coal seam increased pillar thickness should also increase to support the weight of the overlying strata. Relatively deep mines will call for pillar thickness to range from four to six yards where shallower mines are on the order of two to three yards (S.I.M., 1884:27). Rooms are generally the same size as the pillars provided a sturdy roof and floor are present. With this plan at least 50% of total coal is mined, the remaining percentage needed for roof support (Harris, 1982). Greater yields are obtained when overlying bedrock is sparse because the volume of the rooms can be increased while pillar thickness is decreased.

The condition of the roof and floor are also important variables that determine pillar and room size. "If the pavement is soft, and the coal and roof strong, pillars of extra size must be left, to prevent the pillars sinking into the pavement and producing a creep (Roy, 1884:306)." The opposite will occur if a soft roof is present.

Since the supporting pillars are cut from the coal, the nature of the coal is an important factor to be considered. When the coal is soft, or has open backs and cutters, thicker pillars must be made or the pressure from the overlying bedrock will cause the pillars to break off at the backs and cutters and subsequently produce a cave-in. This factor alone is of vital importance and if overlooked could cause the destruction of the whole mine (Roy, 1884: 306).

Figure 10 is a layout of an idealized double entry room and pillar mine. It consists of two parallel galleries (Butt Entries) extending into the coal seam upon which adjacent rooms are worked off of perpendicular to the galleries. Galleries serve as the main passageways for the transportation of empty and loaded bank cars. The loaded bank cars traveled from the rooms to the main shaft and were often pulled by ponies, mules, large dogs or the miners themselves (Harris, 1982). Mining started at the main entryway where the rooms were made the largest. As mining progressed rooms were made smaller in order to stabilize the entire system. Ventilation is shown by directional arrows. Butt entries were sealed as additional rooms were added to circulate the air through the rooms (Roy,1884:328).

"After the rooms are all worked out by the system of leaving strong pillars, the pillars are attacked at the far end of the mine and worked back, the miners retreating under cover of the remaining pillars (Roy, 1884:309)." Pillar "robbing" is the most dangerous part of mining and often results in the instability of the entire mine (S.I.M., 1884: 27). Plate 1 is a map of the Church Hill Slope, Trumbull County, which was mined by the room and pillar method during the late 1800's.

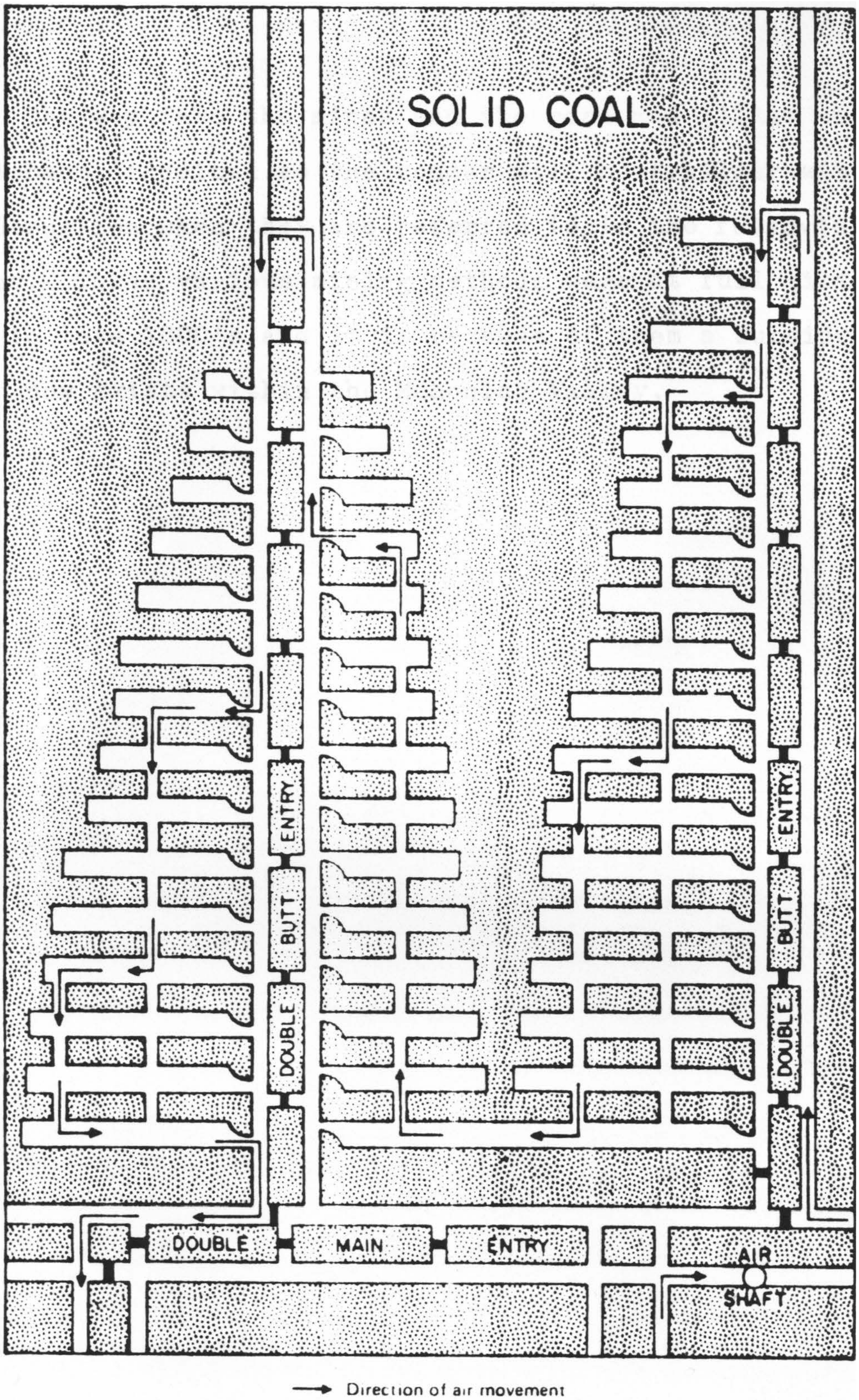


Figure 10- Idealized double-entry room and pillar mine layout. (Crouch et al., 1979:16)

The way into the mines and the room and pillar method have been described so the reader will be familiar with their construction when they are referred to in the following sections. These various mining methods were at full tilt in the mid to late 1800's and it is because of them a subsidence problem now exists within the Mahoning Valley.

VI. MINING HISTORY OF THE MAHONING VALLEY

Economic Geology

Coal mining began in the Mahoning Valley around the 1830's with the opening of one of its first mines in the Weathersfield Mineral Ridge area (1835),Trumbull County (Sharrow, no date). In the following years coal mining thrived and many people settled in the area to mine the valuable coal and Blackband iron ore. Because the coal was such an excellent fuel for blast furnace use it provided for the development of the steel industry throughout the Mahoning Valley. Evidence of this development is provided by a historical report written by J. C. Sharrow (no date), a Mineral Ridge resident:

> The settlement of Mineral Ridge followed closely on the centering of attention to a coal mine opened in Weathersfield and Ohltown and it was not long until larger mines were opened at Mineral Ridge. The starting of the mines brought many people to Mineral Ridge; with the opening of the mines came the railroads (built in 1857).
>
> In 1858 Jonathan Warner in company with James Woods of Pittsburgh erected the first furnace in Mineral Ridge. It was known as the Ashland Furnace and was built for the purpose of manufacturing pig iron from the coal and blackband ore.

Production

In 1875 Ohio mined 4,868,252 tons of coal *(Table 6). Of this nearly five million tons, 21% of it came from the mines of Mahoning and Trumbull counties. Of the 26 counties reporting coal yields for 1875, Trumbull ranked first and Mahoning eighth in total production *(Table 6). Eleven years later in 1886 total production for Mahoning and Trumbull counties was

*--located in appendix A

only 501,571 tons, down 50% from 1875. "The loss in Trumbull County, both in tonnage and miners, is largely attributable to some of her largest producing mines having been worked out and abandoned during the year (S.I.M., 1887:19)." This decrease continued and by 1905 the production ranking of Mahoning County was 21 and that of Trumbull 29 out of the 29 counties reporting for the year. By 1913 the Ohio Coal Mining Commission reported (1913:9):

> The days of coal mining this seam are about over and the deposits now being mined are nearly exhausted and there is no considerable body of this coal of a thickness sufficient to make mining worth while which has not already been attacked.

VII. THE EFFECT TODAY

Problem

The Mahoning Valley was reminded of its mining history in 1977 when the floor of a double car garage fell into a 230 foot deep shaft. During the next few years the subsidence problem progressed and by 1982 more than 30 mine entrances had collapsed. The problem still exists today with subsidence occurring over shaft, slope, and drift entryways. Subsidence over rooms is not a major problem yet but will become one in the future as supporting pillars grow weak and start to collapse (Harris, 1982).

Local residents have no knowledge as to the location of these entryways and mines because very few mining records were kept. Homes which were built unknowingly over or adjacent to mining areas are in great danger today due to the increased subsidence. Because of the ignorance of some, building permits were issued to contractors where known mining operations had taken place. These contractors then constructed individual homes and housing projects in these areas because it was "convenient", and now these homes are in great danger (Harris, 1982).

Answers

On August 3, 1977 Public Law 95.87 (Surface Mining Control and Reclamation Act) was passed by congress. Title IV-Abandoned Mine Reclamation of this act allocated the establishment of a self-supporting trust fund within the U. S. Treasury "to restore lands ravaged by uncontrolled mining operations in the past (CQ Almanac, 1977:618)."

In the Mahoning Valley this bill "provided for the filling of voids and the sealing of abandoned tunnels, shafts and entryways, and reclamation of other surface impacts of mining (CQ Almanac, 1977:619)." Unfortunately, federal funding and homeowners insurance do not provide for property damages caused by subsidence to public landowners.

The Role of Ann G. Harris

Ann Harris is an Associate Professor of Geological Sciences at Youngstown State University. She became involved in mine subsidence after the collapse of the first mine shaft (Foster #1) in 1977. In addition to her teaching profession she also works for the state as consulting geologist to the subsidence problem (Harris, 1985).

When a mine stabilizing job is approved by the state, engineering firms are hired to do the necessary work. Hiring is done by competitive bidding and Ann Harris is responsible for providing the background information so each firm can analyze the materials needed to make their bid. She then accompanies the firm to the job to advise when questions are raised concerning the the stabilization procedure (Harris, 1985).

The state with the help of Ann Harris is also making an effort to locate the Sharon coal throughout the Mahoning Valley. This is done by exploration drill teams (Photo 1).

The drilling teams travel throughout the valley taking core samples (Photo 2). If the horizon of the Sharon coal is located it is then mapped and the team moves on to another position. Drilling is done to determine the Sharon coal's elevation and outcrop pattern throughout the valley. This important information is needed in order to map the mined areas so new building programs are not in danger of subsidence damages (Harris, 1985).

VIII. TYPES OF SUBSIDENCE

Factors

There are many factors affecting subsidence over entryways and mines. The most common ones are listed below and their relationship to the type of subsidence will be commented on (Harris, 1985).

1. Depth to mine.
2. Type and amount of cover (Bedrock and soil).
3. Tunnel and mine height.
4. Roof and floor conditions.
5. Extent of pillar "robbing".
6. Method of sealing openings.
7. Time.
8. Condition of man-made supports.

Drift Subsidence

Subsidence over drift entryways are most common on the hillside which was penetrated. When a drift entryway becomes weak superincumbent strata develop stress cracks and joints and eventually cave-in follows forming large concave up dish shaped impressions on the hillside face. Factors effecting drift entry subsidence are type and amount of cover, conditions of man-made supports, and time. Drift entryways were often timbered at the hillside face for roof support (Fig. 7). As time progressed the weight of the overlying strata was often too much for the timber supports and subsidence occurred. The type of roof is also a factor. If a shale roof is present, subsidence usually follows because shale roofs are very weak (Harris, 1982).

Slope Subsidence

Usually all the factors listed above contribute to slope subsidence, the most prominent being type and amount of cover. When there is little cover over the slope entryway surface loading and time contribute to its subsidence. Roads were often built over these shallow entryways and as time progresses subsidence eventually occurs causing sections of the road to be engulfed. The type of bedrock is another important factor. As shown in figure 8, slope entryways cut through bedrock zones. When a weak zone such as shale is cut through subsidence usually follows and, if depth is shallow, surface features will be present (Harris, 1982).

Shaft Subsidence

Shaft subsidence is the most common type found in the Mahoning Valley and "is potentially the most dangerous (Harris, 1982)." Factors which contribute to shaft subsidence are method of sealing the entryway and time. The main cause for shaft subsidence is improper filling techniques incorporated upon the closure of the mining operations around the turn of the century. These vertical shafts, sometines as deep as 250 feet, were filled with trash, garbage, and waste material from the mine. In some cases even cars (two 1921 Model A Fords) were used as fill material as was discovered in the Foster/Crane Shaft. Wooden railroad ties were then placed directly over the cribbing and the pit around the shaft was then filled in with topsoil and graded. The subsidence problem exists today because the timbers and garbage within the mine have rotted away creating voids which cause the surface to subside and cave in. Water conditions within the mine have also accelerated this process by washing fill material into the lateral tunnels (Harris, 1982).

Room and Tunnel (Gallery) Subsidence

Subsidence over rooms and tunnels produces surface structures called subsidence pits (Fig. 11). The degree of surface deformation of subsidence pits is dependent upon the depth to the mine, type and amount of roof cover, and tunnel and mine height. Rooms and tunnels which have shallow depth, little cover, and high ceilings will produce the greatest amount of surface deformation. The surface area of a subsidence pit is dependent upon the area of the underlying room or tunnel. "Most subsidence pits are shallow, but some are as deep as 15 to 20 feet and most have a diameter of less than 15 feet (Harris, 1982)." Subsidence pits over tunnels may also show maximun depth of 15 to 20 feet but they are usually only two or three feet in width. The other factor that produces subsidence pits is the condition of the roof and floor. This type of subsidence is caused by pillar creep and has been discussed in section V (Harris, 1982).

Figure 11- A subsidence pit over a room in the middle of a proposed road for a subdivision. (Harris, 1982)

IX. FILED REPORTS

The Foster #1 Shaft

The following report is one of many that exist within the personal files of Mrs. Harris. It is cited because it exhibits the most common type of subsidence in the area (Harris, 1982).

> The Foster #1 Shaft was the first shaft to cave-in in the Youngstown area, June 13, 1977. It was beneath a double car garage and claimed almost the entire garage floor except for three feet around the base of the garage walls. Measurements taken after the cave-in showed that there was 13 feet of cover material over the 8' x 8' railroad ties that originally capped the 9' x 18' shaft at bedrock level. Beneath the railroad ties, there was a 60 foot void, 57 feet of water, and 115 feet of fill material still in the shaft. Thus the actual depth of the shaft is 232 feet deep. With each rainstorm, the depression around the shaft would increase in diameter, until the entire floor of the garage fell in and the hole extended beyond the sides of the garage with only the four corners of the building resting on soil.
>
> When the back wall of the building started to separate, the garage was shoved into the shaft because the roof and parts of the wall would block the shaft if it were to fall in by itself. The shaft was filled by the City Engineering Department with sandstone and capped by a reinforced 6 inch thick concrete cap that extended three feet beyond the cribbing (at bedrock level) in every direction. To prevent further slippage, the center of the cap was 12 inches thick and fitted inside the cribbing to help brace the sides and prevent further cave-ins if the fill material were to withdraw from the shaft and flow into the lateral tunnels. The 13 foot deep by 22 foot diameter pit around the shaft was then filled in with fill material and seeded.

The Foster/Crane Shaft

Photo 3 shows the work that was being done on the Foster/Crane Shaft, Mahoning County. When I took this picture in early May of 1985 the mine was being filled with concrete. This shaft could not be filled with sandstone or building material because of a water problem. Engineers then decided to sink four steel pipes into the shaft and pump concrete into it. The shaft is greater than 145 feet deep and approximately 200 square yards of concrete have been pumped into it already. I talked to Mrs. Harris again toward the end of May and she informed me that they were having problems stabilizing this shaft. Apparently the water problem is so extensive that the concrete is not solidifying. To correct this problem a bonding chemical is going to be pumped into the shaft which will hopefully solidify the concrete.

Veach and Burnett Mine (Slope)

As stated earlier subsidence over slope entries commonly occurs over areas where there is shallow cover. This was the case with the cave-in of the Veach and Burnett mine, Trumbull County. This slope entryway caved in because a road was constructed over the entryway and the surface loading eventually lead to its collapse. "During the summer of 1978, a farmer was driving his tractor to a hayfield when half the road fell in forming a depression about 12 feet wide and 18 feet long (Harris, 1982)." Harris adds that the depression has been stabilized but since there is no history or maps available on this mine it is "not known how extensive this mine is, nor the amount or type of cover (1982)."

Subsidence Over Rooms and Tunnels

As stated earlier subsidence over rooms and tunnels forms surface features called subsidence pits (Fig. 11). These subsidence pits are starting to become a major problem in the area due to increased surface loading and weakening of pillars. An example of the damage of room subsidence can be seen in figure 12. This house is located in Neshannock Township, Mercer County, Pennsylvania. The room beneath the house has collapsed causing the house to lean about one foot out of plumb. The subsidence seems to have stabilized and no additional leaning has been reported (Harris, 1982).

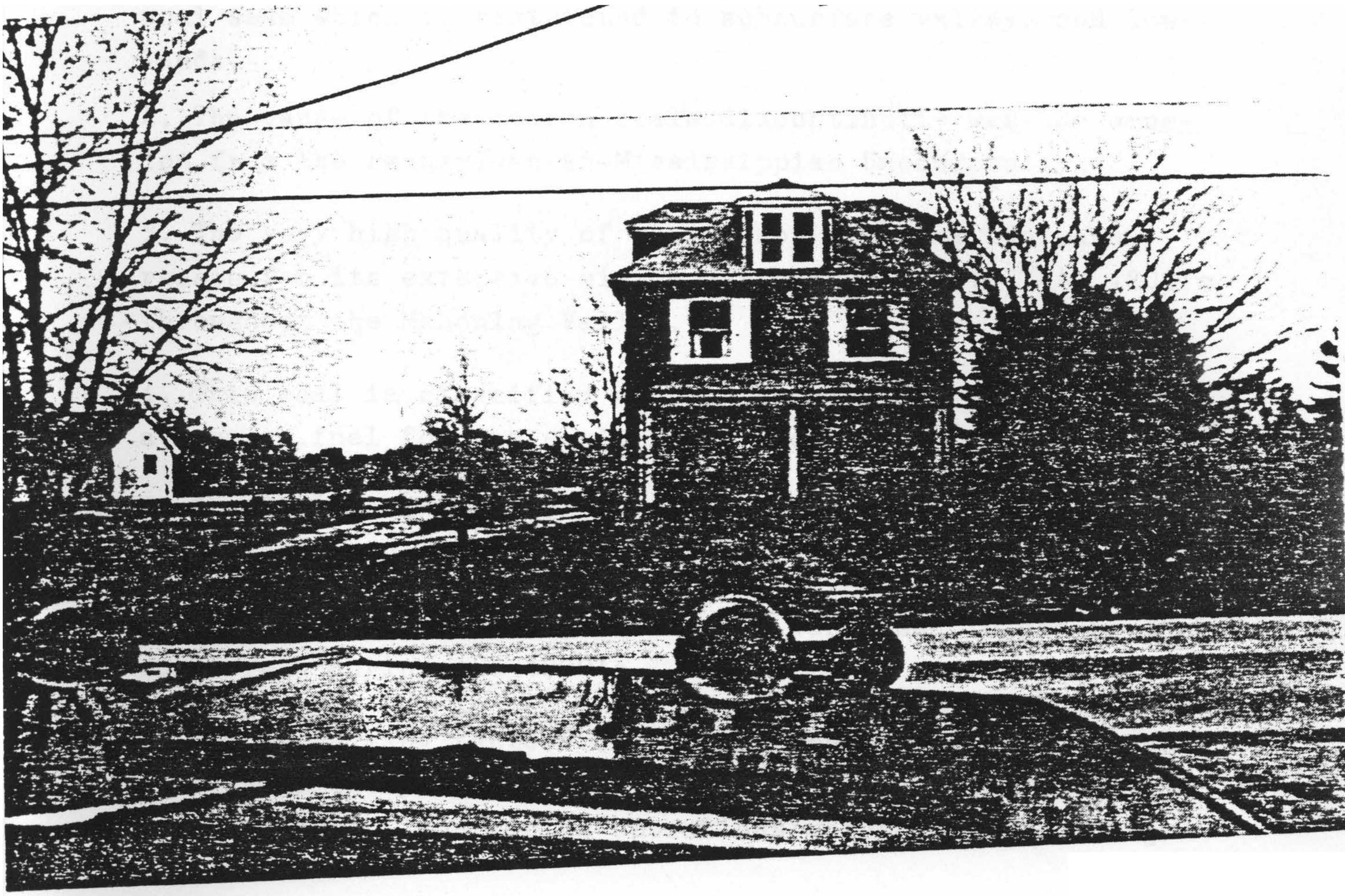


Figure 12- Subsidence over a tunnel has caused this house in Neshannock Township, Mercer County, Pennsylvania to lean about one foot out of plumb. (Harris, 1982

X. CONCLUSION AND RECOMMENDATIONS

Conclusions

1. The Sharon coal is a basin coal. It is a non-continuous coal seam which is restricted to subsurface valleys and lowlands.

2. The cause of the Sharon coal's discontinuity was the erosion from the Pennsylvanian-Mississippian Unconformity.

3. The very high quality of the Sharon coal was the main reason for its extensive mining during the mid to late 1800's throughout the Mahoning Valley.

4. This coal is classified as open-burning and was used as a furnace fuel for the smelting of iron ores.

5. The Blackband iron ore of the Mineral Ridge coal field was a main reason for the extensive mining in that region.

6. Drift, Slope, and Shaft entryways were used to get to the coal mines during the 1800's.

7. There are many factors which contribute to the subsidence over these entryways some of which can be traced back to the carelessness of the mining operations which existed during the 1800's.

8. Room and Pillar mines were the most common type of coal mines during the 1800's.

9. Subsidence over rooms and tunnels can be attributed to the weakening of the pillars due to robbing and surface loading. Other contributing factors which lead to subsidence pits are depth to the mine, roof and floor conditions, and the nature of the coal.

11. Funding for abandoned mine reclamation is provided by The Surface Mining Control and Reclamation Act of 1977.

12. Due to the success of this program approximately 35 abandoned entryways and rooms have been stabilized since 1977.

13. Drilling teams have also added to the success of this program by locating the Sharon coal outcrop pattern and elevation throughout the Mahoning Valley. This information is necessary to advise building developers so they are not in danger of subsidence damages.

Recommendations

The following recommendations were obtained from the last interview that I had with Ann Harris, late May of 1985.

1. State policy has limited the funding of each stabilization job to $50,000 per job. Funding should be more in some cases because each job varies in character.

2. There is a need for more test drilling than the program has allocated. This is needed to:

    a.) Eliminate large areas where the Sharon coal is not located.

    b.) Get an exact elevation of the Sharon coal when it is located.

3. There is a need for subsurface video equipment to observe the conditions of the rooms, pillars, and tunnels of abandoned underground coal mines.

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APPENDIX A

YEAR	MAHONING CO.	TRUMBULL CO.	# COUNTIES REPORTING	RANK MO	RANK TR	STATE PRODUCTION
1875	271,689	749,059	26	8	1	4,868,252
1880	347,635	673,206	30	8	2	7,000,000
1883	223,740	437,612	24	12	6	8,229,429
1884	241,599	257,683	27	14	11	7,650,062
1885	275,944	264,517	27	10	12	7,816,179
1886	313,040	188,531	28	9	15	8,435,211
1887	272,349	167,989	28	12	16	10,301,708
1888	231,035	157,826	27	13	17	10,910,946
1890	228,761	105,333	28	13	18	11,788,859
1891	232,346	64,173	27	?	22	13,050,187
1894	97,062	33,137	?	?	?	11,910,219
1897	92,283	10,838	?	?	?	12,448,822
1899	74,309	11,059	?	?	?	15,908,934
1900	109,348	19,181	30	17	24	19,426,649
1905	117,074	3,591	29	21	29	25,834,657

TABLE 6: Production of coal mined in Mahoning & Trumbull counties, their ranking, and entire state production from the years 1875-1905. Compiled from: Ohio State Inspector of Mines Annual Reports, from the years 1875 to 1905.

PHOTO 1-Drill team in Mineral Ridge.

PHOTO 2-Sample cores taken from drill team in Mineral Ridge. Coal not found.

PHOTO 3-Concrete being pumped into Foster/Crane Shaft.

APPENDIX C

PHOTOS 4 & 5-Abandoned Shaft entryway in Mineral Ridge